same act is thrown back so as to bring the entire weight upon the firmly planted hind feet, in which, and in the thighs, and on the back the muscles are powerful, hence comes the tremendous spring. In alighting, the forward feet nearly close together, touch the ground first; then come down the hinder feet, striking outside and forward of the front feet. Thus is made a double track, the large and wide one outside and forward of the small one, like the kangaroo's track, with this singular difference, the latter makes his double tracks walking, for when leaping the fore feet do not touch the ground. These peculiarities of rabbit tracks were noticed by that delightful naturalist, Robert Kennicott, in 1857, who adds: "In making the longest leaps the fore feet strike in a line, one behind the other, and at some distance in the rear of the hind ones, as if they had been again raised before the latter had touched the surface." It is noticeable that when in quest of food on the snow, their tracks are made of leaps about four feet long.

The strategic tact and knowingness of the wild rabbit was well understood by the plantation negroes, who held the little fellow in an affection not less than that of the Feejee for fat missionary. The upper side of the rabbit's tail is brown, but it has a persistence in showing the under side, which is like a toilet puff, cottony white. The tail being ordinarily carried erect, looks like a tuft of pure clean cotton, or a fresh opened cotton ball, hence its familiar name among the negroes—"little cotton tail." Uncle Remus, though partial, always gets fraternal when on this subject, and makes the cunning "brer rabbit" circumvent the slyness of "brer fox."

(To be continued.)

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THE CRUSTACEAN NEBALIA AND ITS FOSSIL ALLIES, REPRESENTING THE ORDER PHYLLOCARIDA.

BY A. S. PACKARD, JR.

I.—The Structure and Development of Nebalia.

A GOOD deal of interest is attached to this little Crustacean, on account of its composite nature and its evident relationship to some curious fossils which are usually placed among the Phyllopods. The following exposition of the structure of *Nebalia bipes*, which is sometimes dredged on our coast, and the remarks on its fossil allies may prove to be of interest to our

readers. The article is taken, by permission, from the advanced sheets of the Twelfth Annual Report of the U. S. Geological Survey of the Territories, F. V. Hayden, in charge.[1]

The species of Nebalia inhabit the sea at moderate depths. We have dredged *N. bipes* on the coast of Labrador in from four to eight fathoms, and on the coast of Puget sound we collected a similar species, just below low-water mark, among fucoids. The following is taken from Baird's British Entomostraca: "Otho Fabricius tells us that it carries its eggs under the thorax during the whole winter; that they *begin to hatch* in the month of April, and that the young are *born* in May. They are very lively, he adds, and adhere to the mother, who appears then to be half dead. The adult swims in a prone state, using its hinder feet to propel it through the water. They are not very active. Montagu informs us that when moving in the water the superior antennæ are in constant motion as well as the abdominal feet, but that the inferior antennæ are usually motionless and brought under the body. They are found, according to Leach, on the south-western and western coasts of England, under stones that lie in the mud, amongst the hollows of the rocks; and Mr. McAndrew dredged it from a considerable depth amongst the Shetland isles."

In *Nebalia bipes* the body is rather slender and somewhat compressed, the anterior half protected by a carapace, beyond the lower edge of which the broad thin phyllopodiform feet do not project.

The carapace.—The head and anterior half of the body, including the thorax and four anterior abdominal segments, are covered by the carapace, which on the lower edge extends below the ends of the thoracic feet, covers the basal joints of the antennæ, and entirely covers the mouth parts. The sides are compressed, and are drawn together over the body by a large but rather weak adductor muscle (Pl. XIV, Fig. 6), situated a little in front of the middle of the thorax. There is no large highly specialized adductor muscle connecting the two sides of the carapace, nor any well-marked round muscular impression in the carapace, such as is characteristic in the Limnadiadæ; nor is there any hinge, a still more characteristic feature in the bivalved Phyllopods. On the contrary, as seen in Pl. XIII, Fig. 3, repre-

[1] I am indebted to Messrs. Sinclair & Son for kindly striking off an edition of the plates from the stones, after the Government edition was printed. To Dr. F. V. Hayden I am indebted for the use of the illustrations.

senting the carapace removed from the body and flattened out, there are no signs of a median hinge-joint.

The nature of the rostrum is one of the diagnostic features of this order. In Nebalia the rostrum is long and narrow, oval, seen from above, terminating in an obtuse point quite far in advance of the head. It is loosely attached to the sinus in the front of the carapace, and thus forms a long, narrow, tongue-like flap, with a free movement up and down. It is thus seen to be rather a movable appendage of the carapace than a solid, immovable continuation of it, as in the Decapoda. Upon removing the carapace and flattening it out, it is seen to be readily comparable with the carapace of Ceratiocaris.

The eyes.—The eyes are mounted upon a stalk, and thus Nebalia may be said to be essentially stalk-eyed. In this respect it is similar to the eye of the Branchipodidæ on the one hand, or to the eye of the Decapoda on the other.

The antennæ.—The two pairs of antennæ are large, well developed, and of nearly equal size in the female, but in the male the second pair extend backward beyond the bases of the caudal appendages. In the 1st pair the stem (scape or protopodite) is seen to be composed of five joints, the 1st, 2d and 4th the longest, the 3d and 5th short. From the scape arises the flagellum or endopodite, which has sixteen well-marked joints, each joint provided externally with numerous setæ; and besides, there arises from the 5th joint of the scape or stem a scale-like unjointed appendage, which may be regarded as an exopodite; if so, then the 1st instead of the 2d antennæ in the Phyllocarida bear a scale-like exopodite; the 2d antennæ in Decapoda bearing the exopodite.

The 2d antennæ have a two-jointed stem or scape (protopodite), and a single, long, many-jointed flagellum or endopodite, the basal joint a large one; no exopodite being present even in a rudimentary form.

The 1st and 2d antennæ are thus seen to be quite unlike those of the Malacostraca, and to resemble those of the Copepods, in that the anterior pair are rather the stouter of the two; but in those Copepods with very long antennæ it should be remembered that they are the 1st and not the 2d pair, as in the male Nebalia. It will thus be seen that while the antennæ of the Phyllocarida are entirely unlike those of the Phyllopoda, they are

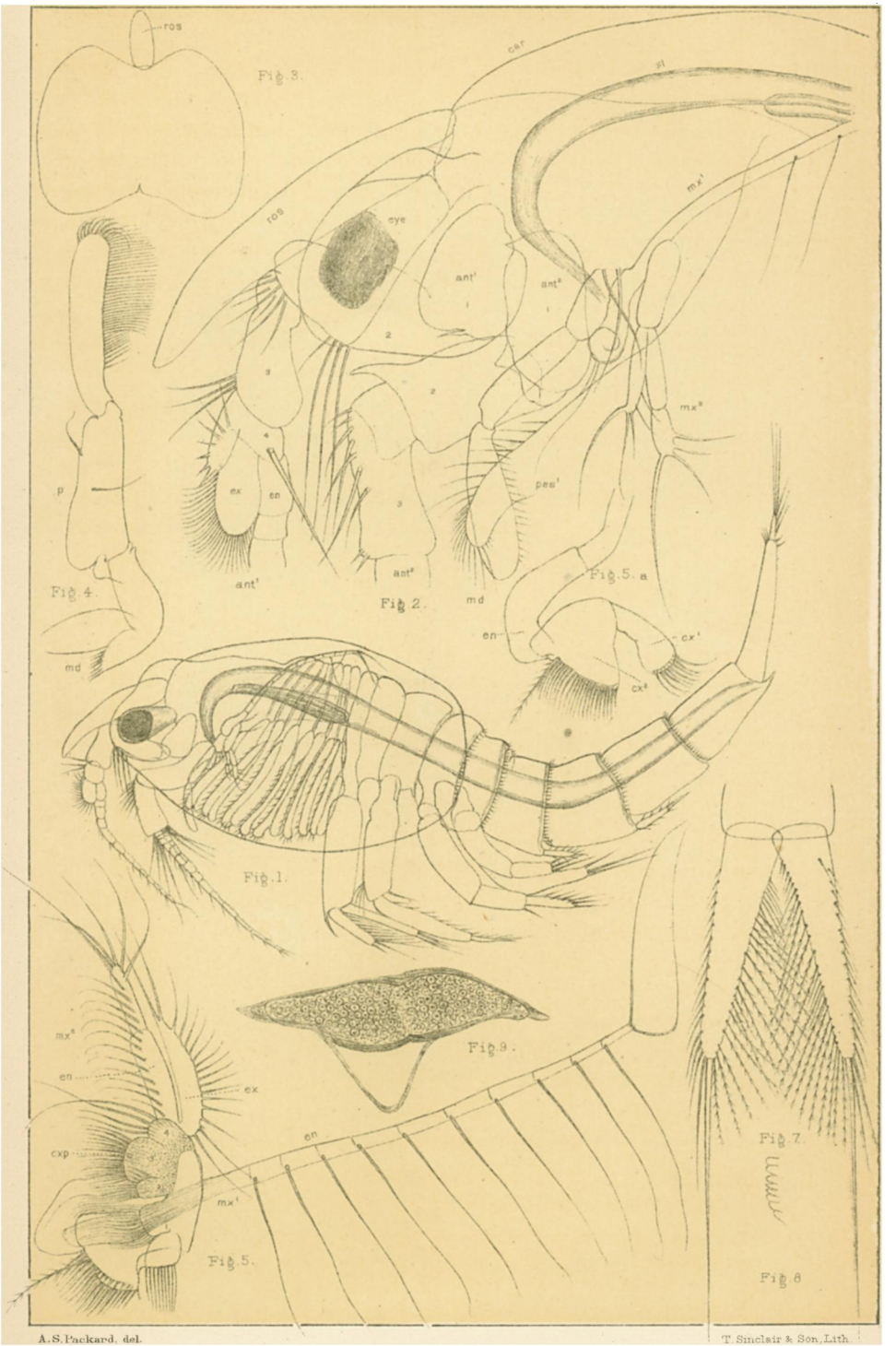
neither closely homologous with those of the Decapoda (Mysis or Cuma) or the Copepoda.

The 2d antennæ of the male is said by Claus to be very long, and to resemble those of male Cumaceæ, but upon a comparison of the stem of the antennæ, it is in Cuma quite different in the relative length of the three joints. So also, while, as Claus observes, they are like the antennæ of the Amphipoda, this resemblance is quite general; on the whole, however, the antennæ of both pair bear a general resemblance to the Malacostracous type; also, on the other hand, they may also be compared with the more primitive Copepodous type.

The mandibles (Pl. XIII, Fig. 4; Fig. 2, *md*).—These are remarkable from the small size and weak development of the biting edge or mandible itself compared with the palpus. The oval or biting end of the protopodite is small, and armed with comparatively few and weak setæ, which shows that the living Phyllocarida probably feed on decaying animal and vegetable food, which is easily brushed into the mouth by their slight stiff bristles. The palpus, however, is enormously developed, extending out quite to, if not a little beyond, the edge of the carapace (Fig. 1). It is three-jointed; the 2d a little longer than the basal, and swollen at the base, while the 3d is somewhat longer but slenderer, and edged with a fringe of close-set, rather stiff setæ. Though so immensely developed as to the palpus, and entirely unlike the mandible of the Phyllopoda, in which only the protopodite is developed, it may be compared with the mandibles of the Decapoda, especially of Mysis and other Schizopods,[1] in which a very long three-jointed palpus is developed. But the very long and large mandibular palpus and very weak protopodite may be set down as a diagnostic feature of the living Phyllocarida, though the mandibles of the fossil species appear to have been much larger.

The 1st Maxilla (Pl. XIII, Fig. 2 mx^1; Fig. 5 mx^1, 5 *a*).—These are likewise singular and diagnostic features of this order, as represented by their structure in the Nebaliadæ. They consist of a small lobe (Fig. 5 *a*, cx^1) with about eight stout setæ, and a larger lobe (cx^2) with the outer edge fringed with long coarse setæ, one of which is a large ciliated seta; from this arises, after bending on itself at its base, an extremely long and slender multiarticulate

[1] Compare G. O. Sars' Monographie over Mysider, 1870, Pl. I, Fig. 8. Claus states that the large palpus is very similar to that of many Amphipoda, but apparently overlooks the still closer resemblance to that of Mysis.



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T. Sinclair & Son, Lith.

ANATOMY OF NEBALIA PIPES

process (or endopodite?) which, in the female, is directed upward and backward (Fig. 5 *a*, *en*), reaching to the tergum of the basal abdominal segment, and ending in two very long, slender setæ, while a few other similar setæ arise, one from each joint.[1] In the male of *N. geoffroyi*, according to Claus, the long setose process is directed forwards and downwards.

The 2d maxilla (Pl. XIII, Figs. 2, 5 mx^2).—These are entirely unlike those of the first pair, and unlike the Decapodous or Phyllopod type. They consist of a basal portion composed of four thin, delicate, unequal lobes (Fig. 5, $^{1, 2; 3, 4}$), edged with long setæ, with two setæ twice as long as the others arising from the 4th lobe; from this four-lobed basal joint or coxopodite, arise two appendages, the anterior (exopodite, *ex*) small, one-jointed; the posterior (endopodite, *en*) two-jointed, the end of the second joint carrying above five long, spreading, stout, slender setæ This two-jointed appendage Claus considers as representing the stock of a palpus.

This pair of maxillæ are quite unlike those of Decapods (Mysis, etc.), as well as those of the Phyllopods, and appear to be another diagnostic feature of the order.

The absence of any maxillipedes, or of any rudiments of them, either in the adult or in the embryo, is a negative character of a good deal of importance when we regard the affinities of the group to the Decapods, or the zoëa-form of the same order, where two (Macrura) and three (Brachyura) pairs of maxillipedes are present, there being three pairs in the adult Decapod.

The eight pairs of Phyllipodiform thoracic feet (Plate XIV, Fig. 3).—The maxillæ are directly succeeded by eight pairs of leaf-like thoracic feet, the maxillipedes not being present. The feet all repeat each other in form, and a description of the 3d or 4th pair will answer for the 1st as well as the last. The leg (Fig. 3, 3d or 4th pair) consists of a broad, thin, six-jointed appendage, the endopodite (*en*), which is fringed with very long, delicate setæ, those arising from the terminal joint being ciliated; while a second series of fine stiff setæ arise obliquely from the edge. To the second joint of the endopodite are appended a distal or lower very broad thin gill, not quite twice as long as broad, and which reaches to the end of the endopodite, while situated more externally is a double, broad, large lobe which corresponds to the exite

[1] Claus draws attention to the position of this foot as compared with the 2d maxillæ (putzfuss) of the Ostracoda.

or flabellum of the Phyllopod foot, this flabellum being as long as the entire endopodite, but not quite so broad as the gill. The distal portion of the flabellum is more pointed than the proximal, and, as will be seen by referring to the figure, is more actively engaged in the process of respiration. The figure shows by the dotted lines of parenchymatous matter the course taken by the blood in passing through the gill and accessory gill or flabellum, and that it must also be partly aerated by the jointed endopodite; the entire appendage, therefore, as in those of the Branchipodidæ, is concerned in respiration. It will thus be seen that the limb is lamellated, but differs essentially from the Phyllopodous limb in that the endopodite is simple, the axis multiarticulate, but sending off no endopodal lobes from the axites, such as form the characteristic feature of the Phyllopodous foot. From overlooking this important and radical difference from the Phyllopodous foot, the earlier observers were led to place Nebalia among the Phyllopods.

In comparing the thin, lamellar, thoracic foot of Nebalia with the thoracic foot of any Decapod, from Cuma to Mysis, and up through the Macrura to the crabs, it will be found impossible to homologize the parts closely, though a general homology is indicated, the endopodite of the Nebalia and the gills corresponding in a general sense to those of the Decapods, and it is this lack of a homology more than any other which forbids us from regarding the Nebalidæ as entitled to take rank under the order of Decapoda, or with any of the Malacostraca. But when we compare the thoracic legs of the adult Nebalia with the maxillipedes of the zoëa of the Decapods, then we can detect a slight and interesting resemblance, but the resemblance and homology is not so close as between the thoracic legs of the Phyllopods and the maxillæ of the early zoëa.

On comparing the broad lamellate thoracic feet of the adult Nebalia with the rudimentary thoracic feet of the later stages of the zoëa, the resemblance is but slight. Just before the zoëa passes into the adult condition the five pairs of thoracic feet of the adult bend out as two-lobed processes; but the resemblance to the leaf-like foot of Nebalia is too remote to be of any taxonomic value; and this remote resemblance shows that Nebalia does not belong to the Decapod type.

The six pairs of abdominal feet (Plate XIV, Figs. 4, 5).—Turning

to the abdominal feet, we find that they are simple, without gills, and entirely different from the leaf-like thoracic appendages, and we have in this differentiation of true abdominal from the thoracic feet a Malacostracan character, one quite unlike the differentiation or blending of the two regions in the Phyllopods.

The abdomen is nine-jointed, the segments cylindrical and edged with obtuse spines (Pl. XIII, Fig. 8) much as in Copepoda.

In their general form the abdominal legs appear to resemble the simple biramous legs of the Copepoda, but still more closely those of the Amphipoda, in which, as Claus observes, there is a similar retinaculum. (See also Milne-Edwards's Crustacea, Pl. 30, Fig. 3[a].)

The 5th and 6th segments of the abdomen bear much smaller, more rudimentary legs. The 1st pair (Pl. XIV, Fig. 5) are seen to be two-jointed, the 2d joint long and slender, bearing near the end stout raptorial setæ, and on the inner edge slender setæ. The 6th pair are still more rudimentary, one-jointed, and with but few setæ, which are stiff and coarse. These resemble the simple unbranched 5th and last pair of abdominal feet in Copepoda (Calanus ♀).

The long, slender terminal segment bears two very long, narrow cercopods (Pl. XIII, Fig. 7) ending in one large and several small setæ, but there is no telson; the cercopods are simple, the integument entirely smooth, with no striæ or any other markings, and they are edged externally with short, and internally with long ciliated setæ. In the absence of a telson Nebalia differs from Cuma or any other Decapod, and in this respect, and the simple cercopods, shows a close resemblance to the terminal segment with its two setiferous cercopods of the Copepoda.

Internal anatomy.—Claus remarks in his "Untersuchungen zur Erforschung der genealogischen Grundlage des Crustacean-Systems" (1876), that in all the internal systems of organs, Nebalia is considerably removed from the Phyllopoda, and shows an immediate relationship to the Malacostraca, sometimes approaching near the Amphipoda, sometimes near the Mysidæ. The nervous system consists of a large two-lobed brain and of a ventral cord extending through all the limb-bearing segments, there being, as shown in Metschnikoff's Fig. 25 of the embryo, seventeen ganglia, corresponding to the seventeen limb-bearing segments of the body behind the head. A transverse section of a ventral

ganglion of *N. bipes* (Pl. XIII, Fig. 9, or Fig. 1, in text, *ng*) shows a form of ganglion quite unlike that of the Estheria and other Phyllopods, in which the ganglia are separate, connected by rather long transverse commissures, whereas in Nebalia the pair of ganglia are consolidated and of the form of the Decapod ganglion, as also pointed out by Claus, who says that there is a very close resemblance in the form of the nervous centers to the ventral ganglionic chain of the Mysidæ.

We have endeavored to obtain good sections of the brain of *Nebalia bipes*, and Fig. 1 in the text will serve to illustrate tolerably well the form and intimate structure of the supra-œsophageal ganglion. The brain is very small, and the section represented was the third from the front of the head. The ovaries (*ov*) pass into the head, the end of each ovary overlying the brain. The brain itself is composed of two lobes closely united, and seen in section the brain is as deep as broad, with a constriction passing around the outside in the middle. The histological structure is very simple, with nothing approaching the complex nature of the Decapodous brain.

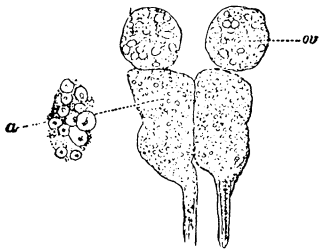

FIG. 1.—Section of the brain of *Nebalia bipes*; *ov*, ovary; *a*, portion of brain still more enlarged to show the ganglion cells. Author del.

In the digestive canal, says Claus, we have a quite specific peculiarity, together with approximations sometimes to the Amphipoda and Isopoda, and sometimes to the Mysidæ and Podophthalmata. The short up-curved œsophagus leads into a stomach with a complicated chitinous armature, in which an anterior and a posterior division can be distinguished.

Our sections of the body of *Nebalia bipes* show that in their general features the digestive canal and appendages are much as Claus describes for the Mediterranean species. We were unable to get good sections of the proventriculus or *kaumagen*.[1] Plate XIV, Fig. 6, evidently passes through the stomach in front of the heart, which is much larger than the intestine (Fig. 2, *i*, in text). Fig. 2 (in text) is a section (No. 9) through the anterior part of the thorax, in the region of the adductor muscle (*add. m*); the heart (*ht*) is quite remote from the small intestine, which is smaller than the two anterior cœca. In Fig. 3 (in text) of section

[1] Our Sections were kindly made by Mr. Norman N. Mason of Providence, R. I.

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14, through the same specimen at the end of the thorax, the

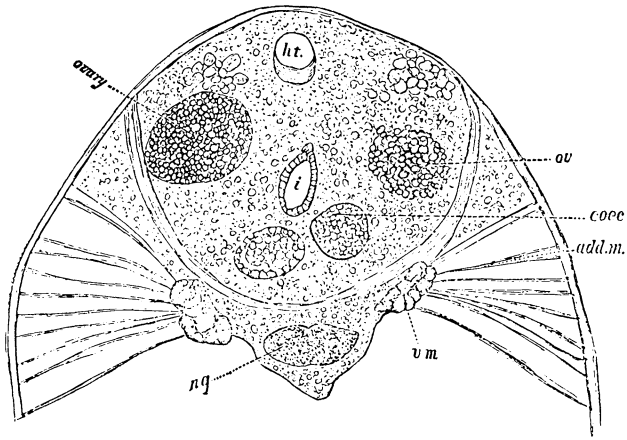

FIG. 2.—Section through the front end of the thorax of *Nebalia bipes*. *ht*, heart; *i*, intestine; *ng*, ganglion; *vm*, ventral muscle. Author, del.

heart (*ht*) is of its maximum size, and now we see sections of six cœcal tubes, the series of four lower ones being the four posterior tubes described by Claus as passing back into the abdomen. In this section the dorsal muscles (*dm*) of the posterior part of the body appear, and the ventral muscles (*vm*) are larger than in section 9, while the ovarian tubes (*ov*) are smaller.

The heart of Nebalia is a long straight tube a little thicker just in front of the middle, beginning over the maxillæ just in front of the 1st thoracic segment (tergite) and extending to the middle of the 4th abdominal segment.

Claus includes Nebalia among the Malacos-

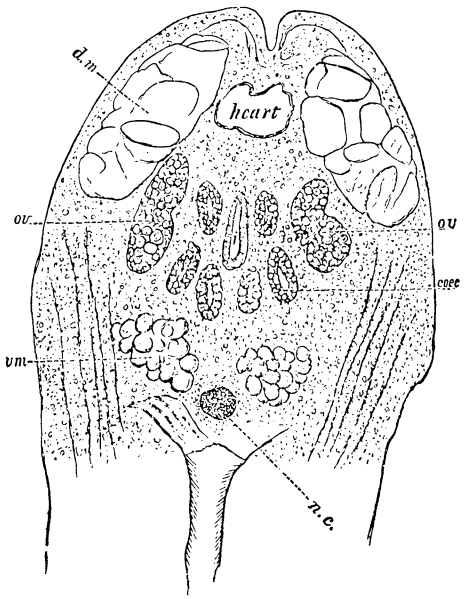

FIG. 3.—Section through the end of thorax of *Nebalia bipes*, showing the six cœca (*cæc*), the heart (*ht*), the ovaries (*ov*), and the sets of muscles; *dm*, dorsal muscles; *vm*, ventral muscles; *nc*, nervous cord; *ov*, ovary; *i*, intestines. Author del.

traca, but when we consider the composite nature of the internal organs as described by him, we wonder that he failed to appreciate the independent, synthetic nature of the Phyllocaridan type which, when we take into account the external as well as internal organization, forbids our regarding Nebalia as a true Malacostracan, though the type of a group standing outside of, but nearer to the Malacostraca than are the Phyllopods.

The development of Nebalia.—Our knowledge of the development of Nebalia is due to the distinguished Russian embryologist, who in 1868 published an elaborate account of the developmental history of *Nebalia geoffroyi.* Unfortunately the pamphlet is in Russian, and only brief abstracts of it have appeared in German. But as ample and well-drawn figures illustrate the work, we can state the salient points in the ontogeny of this interesting Crustacean. The yolk does not undergo total division, but by the subdivision of a large polar cell the yolk becomes surrounded by a layer of blastodermic cells. Soon after the rudiments of the two pairs of antennæ and of the mandibles bud out, the abdomen also being differentiated from the rest of the body (Pl. xv, Fig. 1). This is regarded as representing the free nauplius condition of other Crustacea. At a succeeding stage (Fig. 2) the two pairs of maxillæ and two pairs of thoracic feet bud out; and in a stage immediately succeeding (Fig. 3) the palpus of the mandibles elongates, the maxillæ are two-branched, and seven (or eight) pairs of thoracic feet are indicated. In a succeeding stage (Fig. 4) Nebalian characters assert themselves; such are the carapace and large rostrum, the biramous anterior pair of antennæ, the unbranched 2d pair, the long mandibular palpus, the absence of any rudiments of maxillipedes, and the eight pairs of thoracic feet (bænopoda) and three pairs of abdominal feet (uropoda), all of which are now well developed. At this stage it may be seen that, as in spiders, the 1st pair of thoracic feet may represent the 2d maxillæ of insects transferred from the head to the thorax; so in Nebalia, the three first of the eight pairs of thoracic feet may correspond to the three pairs of maxillipedes of Decapods, which in early life, before the thorax is differentiated from the head, may have remained afterwards as a part of the thorax. An intermediate step is the retention in the Mysidæ of the last pair of maxillipedes or the 1st pair of thoracic feet, so that these Crustacea have six pairs of feet. Moreover, Nebalia

at this time, in the absence of differentiation of the thorax from the abdomen, and of thoracic and abdominal feet, the two sets being similar in form and development to each other, may also represent the Phyllopod stage. In the next stage, at the time Nebalia leaves the brood sac of the mother, it is but one step removed, so to speak, from the adult form.

Metschnikoff's observations were made on *Nebalia geoffroyi* of the Mediterranean sea. We have in our sections of *Nebalia bipes* observed stages of development in the young similar to the stages represented by Metschnikoff's Fig. 13 or 14, and have found in the bottom of the vial in which the specimens were sent, several young which had fallen out of the brood sac of the parent. Upon comparing these with Metschnikoff's Fig. 19, or Fig. 5, Pl. XV, they are of the same form; the rostrum being large, the procephalic lobes large, the eyes small, the stalks not yet developed, while the maxillary palpus stretches back to the 1st abdominal feet; the thoracic feet are covered by the large carapace, and a 4th pair of abdominal feet have developed, while the caudal appendages are as in the adult. In all these features we see only a general resemblance to the Schizopods of any value, the similar earliest phases of development proving of no special importance.

Comparison between the early stages of Nebalia and the Decapod (Schizopod) Mysis.—It would appear that if Nebalia were a Decapod, that in its larval stage it should present a close homology with Schizopods at a similar stage of existence. In Euphausia the young leaves the egg and becomes a free-swimming nauplius, and then a protozoëa, and at length a zoëa larva before assuming the adult condition. It is evident that since Nebalia passes its early stages in the incubatory pouch of the mother, that it should be rather compared with the young, when about ready to leave the mother, of some Mysis-like form.

Happily, Professor G. O. Sars has afforded us the material for such a comparison. The early stages of Mysis, as worked out by Van Beneden and Claparède, and of Nebalia, are much alike; the formation of the blastoderm is much the same. The nauplius stage in the egg is nearly identical in both, but beyond this the parallelism ceases to be an exact one; Nebalia turns off and follows quite a different developmental path from Mysis or any Decapod. If we compare the young of Nebalia, taken from the brood-sac, with that of Mysis, as figured by Claparède (Plate

XVII, Fig. 6), or a more advanced stage, particularly that of *Pseudomma roseum*, as figured by Sars,[1] we shall find that many of the differential characters which, in the adult, separate the Phyllocarida from the Decapoda, are to be found in the young. In Mysis and allies at the same stage as Metschnikoff's Fig. 18 of Nebalia (our Plate XV, Fig. 4), the 2d antennæ are simple instead of being bifid as in Nebalia; there are no maxillipedes, and the maxillæ are, as in the adult, immediately succeeded by the eight pairs of thoracic feet; moreover, there are no abdominal feet in Mysis or Pseudomma, while three pairs are present in the young Nebalia. But with the exception of the lack of abdominal feet in the Mysidæ at this stage, it may be thought upon the whole, as has already been stated by Balfour, that "the development of Nebalia is abbreviated, but from Metschnikoff's figures may be seen to resemble closely that of Mysis. * * * There is in the egg a nauplius stage with three [pairs of] appendages, and subsequently a stage with the zoëa appendages." It seems to us that the comparison[2] here made is, as regards any resemblance to a zoëa, loose and inexact, whether applied to the Mysidæ or to the Phyllocarida. The stage of the Mysidæ succeeding the nauplius is characterized by the presence of the rudiments of eight pairs of appendages, the two pairs of maxillæ, and the six pairs of thoracic feet of the Schizopodous type, while the zoëa has no thoracic feet at all, so that it would appear that the Schizopods do not pass through a genuine zoëa state like that of the higher Decapods. Nor on the other hand is the Nebalia stage represented by Metschnikoff's Fig. 18 (our Fig. 4) a zoëa stage, for the embryo has the rudiments of eight pairs of thoracic feet, and besides those of three pairs of abdominal feet, while there is a well-marked carapace and rostrum, as well as procephalic lobes with eyes, all these parts not being developed in the embryo Mysidæ.

But whatever may be said of the resemblances between Nebalia and the Mysidæ at an early period after the nauplius stage has been discarded, when we compare the later stage represented by Metschnikoff's Fig. 19 (our Fig. 5, Plate XV) with the latest larval stage of Pseudomma (see Sars's Fig. 23, our Plate XV, Fig. 6),

[1] G. O. Sars, Monog. over Mysider, Heft. 1, Taf. IV, Fig. 23.

[2] Claus (Genealog. Gundlage des Crust. Systems, p. 31), as we find since writing the above, does not accept Metschnikoff's comparison of the young Nebalia with the zoëa, although he does not give the reasons for his dissent.

PLATE XV.

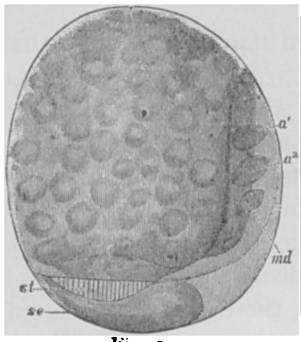

Fig. 1.

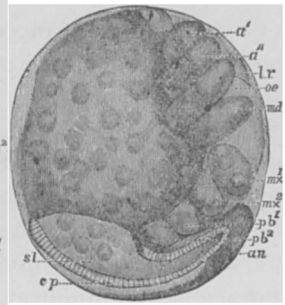

Fig. 2.

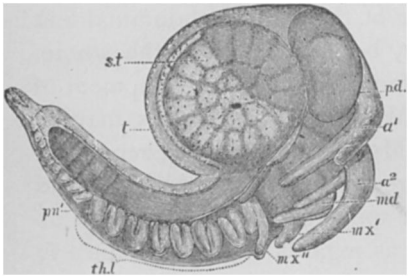

Fig. 3

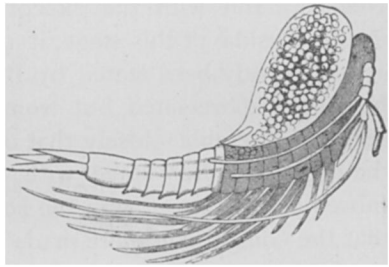

Fig. 6.

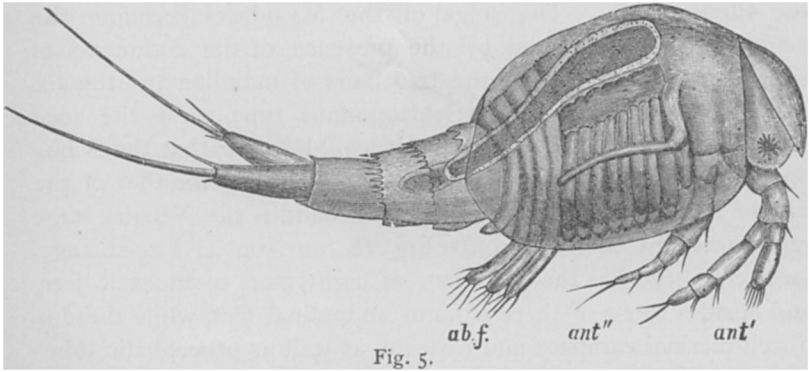

Fig. 5.

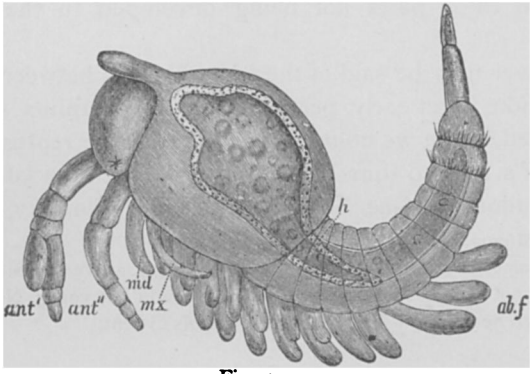

Fig. 4.

THE EMBRYOLOGY OF NEBALIA.

then we see that the diagnostic ordinal characters of the Phyllocarida have declared themselves. There are to be seen in Nebalia the large movable rostrum, the compressed pseudobivalvular carapace, the lack of maxillipedes, the eight pseudophyllopod thoracic feet, and four pairs of abdominal feet, out of the six of the adult. On the other hand, in Mysis of the same stage, the two pairs of maxillipedes are well developed, and the six pairs of remarkably long thoracic feet (the first pair modified maxillipedes) are present. There is little to indicate that the Schizopods have descended from a Nebalia-like form, but rather from some accelerated zoëa form; while, as we attempt in this essay to show, the Phyllocarida have had no Decapod blood in them, so to speak, but have descended by a separate line from Copepod-like ancestors, and culminated and even began to disappear before any Malacostraca, at least in any numbers, appeared.

EXPLANATION OF PLATE XIII.

FIG. 1.—*Nebalia bipes* Kroyer; female, much enlarged.
" 2.—*Nebalia bipes* Kroyer, female, head; *ros*, rostrum; *car*, carapace; *ant*^{1}, 1st antenna, (1–5) five basal joints; *ex*, exopodite; *en*, endopodite; *ant*^{2}, 2d antenna, with 1–3 three basal joints; *pes*^{1}, part of first pair of feet; *md*, mandible; *mx*^{1}, first maxilla; *mx*^{2}, second maxilla; *st*, stomach.
" 3.—The carapace flattened out to show relations of rostrum.
" 4.—Mandible, *md*, cutting edge; *p*, palpus.
" 5.—The two maxillæ; 1–4, the four lobes of the coxopodite.
" 5*a*.—1st maxilla; *cx*^{1}, *cx*^{2}, coxopodites; *en*, endopodite.
" 6.—(Omitted.)
" 7.—Cercopoda or caudal stylets.
" 8.—Portion of dentate edge of an abdominal segment.
" 9.—Section through a ventral ganglion.

EXPLANATION OF PLATE XIV.

FIG. 1.—*Nebalia bipes* Kr. ♀; 1st antenna; lettering as in Pl. XIII; *k*, lobe from 4th joint.
" 2.—2d antenna.
" 3.—One of the 3d or 4th pair of thoracic feet; *fl*, flabellum; *ex*, exopodite; *en*, endopodite.
" 4.—One of 2d pair of abdominal legs; *ret*, retinaculum; *en*, endopodite; *ex*, exopodite.
" 5.—One of the fifth pair of abdominal feet.
" 6.—Section through the body just behind the first pair of thoracic feet, through the stomach (*st*), and the two anterior cœca (*cæc*); *add. mus*, adductor muscle; *sh*, shell.
" 7.—Section through one of the cœca.

EXPLANATION OF PLATE XV.

FIG. 1.—Nauplius stage of *Nebalia geoffroyi*.
" 2.—Farther advanced embryo.
" 3.—Still older stage, with the thoracic feet.
" 4.—Advanced embryo.
" 5.—Embryo ready to hatch.
" 6.—Embryo of Pseudomma about ready to hatch. (After Sars.)

Figs. 1–5 copied from Metschnikoff.